

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Xiao Dong Xiang et al

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Examiner:

Title: "SPATIALLY RESOLVED SPIN RESONANCE DETECTION"

Commissioner of Patents and Trademarks

Washington, D.C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

In accordance with 37 C.F.R. 1.115, please enter the following preliminary amendments to the claims of the above-identified patent application. Cancel claims 1-44 and replace these by claims 45-66, which read as follows.

1-44 (cancelled)

45 (new). A method for determining electrical impedance associated with a material sample, the method comprising:

providing an excitation signal, having an excitation electromagnetic field with a selected excitation electromagnetic field direction in a sample, the excitation signal having at least one of a substantially static amplitude and a time varying amplitude with a selected frequency component f_{exc} ;

allowing the excitation field to interact with a selected portion of the sample, and to produce an impedance signal arising from the sample portion;

using an evanescent wave probe, located adjacent to the sample, to perform at least one of (i) excitation and (ii) sensing of the impedance signal for the sample portion;

providing a sensing mechanism having a detection port to detect the impedance signal for the sample portion;

providing a signal cancellation mechanism that suppresses presence of the excitation signal at the frequency f_{exc} at the detection port when the impedance signal is sensed;

providing low noise amplification of the signal sensed after suppression of the presence of the excitation signal at the detection port; and

detecting the amplified signal of the impedance as an output signal.

46 (new). The method of claim 45, further comprising choosing said excitation frequency f_{exc} in the radiofrequency or microwave range.

47 (new). The method of claim 45, further comprising

providing an input signal coupler and an output signal coupler for a resonator, having a resonant frequency f_{res} and being associated with said probe, and choosing said frequency f_{exc} to be substantially equal to f_{res} .

48 (new). The method of claim 47, further comprising providing said resonator as a cavity-type resonator and providing said evanescent wave probe as an aperture at a selected

location in a shielding wall of said resonator.

49 (new). The method of claim 47, further comprising locating said aperture at a position where a magnetic resonance field strength corresponding to said frequency f_{exc} has an approximately maximum value.

50 (new). The method of claim 47, further comprising choosing said resonator to be a transmission line-type resonator, comprising a center conductor connected to said evanescent wave probe.

51 (new). The method of claim 50, further comprising drawing said resonator from a group of transmission line-type resonators consisting of a stripline, a microstrip line and a coaxial line resonator.

52 (new). The method of claim 50, further comprising choosing said evanescent wave probe to comprise a small radius electromagnetic loop connecting said center conductor to a ground plane.

53 (new). The method of claim 52, further comprising:
providing said resonator with electromagnetic shielding having a small aperture; and
locating at least a portion of said loop in the resonator aperture.

54 (new). The method of claim 50, further comprising choosing said evanescent wave probe to comprise a small diameter, electrically conducting wire with a tip having a small radius, connected to said center conductor.

55 (new). The method of claim 54, further comprising:

providing said resonator with electromagnetic shielding having a small aperture; and
locating at least a portion of said tip in the resonator aperture.

56 (new). The method of claim 45, further comprising:

providing an input signal coupler and an output signal coupler for a resonator, associated with said probe and having at least first and second degenerate orthogonal modes with an associated resonant frequency substantially equal to f_{exc} ;

arranging for the input coupler and said probe to strongly couple to the first degenerate mode and for the output coupler to strongly couple to the second degenerate mode;

causing said probe to emit said excitation signal to said sample portion; and

sensing a non-zero portion of said output signal with frequency component f_{res} at the output coupler, representing said interaction of said evanescent wave with said sample portion.

57 (new). The method of claim 56, further comprising:

adjusting at least one parameter associated with at least one of said input coupler, said output coupler and said resonator so that, when said sample is absent, an amplitude of said output signal received at said output coupler is minimized; and

sensing said impedance signal at said output coupler when said sample is present.

58 (new). The method of claim 56, further comprising providing said resonator as a stripline or microstrip resonator.

59 (new). The method of claim 58, further comprising:

providing said resonator with a substantially square center conductor, and arranging for said input coupler to couple to a first edge of the conductor, and for said output coupler to couple to a second edge, orthogonal to the first edge, of the conductor;

choosing said evanescent wave probe to comprise a small radius, electromagnetic loop connecting the center conductor to an edge opposite the first edge of the conductor; and

choosing a dimension of each side of the center conductor to be $n\lambda$, where n is a selected non-zero integer and λ is a wavelength corresponding to said excitation frequency f_{exc} .

60 (new). The method of claim 58, further comprising:

providing said resonator with a substantially square center conductor, and arranging for said input coupler to couple to said probe and to a first edge of the conductor, and for said output coupler to couple to a second edge, orthogonal to the first edge, of the conductor;

choosing said evanescent wave probe to comprise a small radius, electrically conducting tip connecting the center conductor to an edge opposite the first edge of the conductor; and

choosing a dimension of each side of the center conductor to be $n\lambda/2$, where n is an odd integer and λ is a wavelength corresponding to said excitation frequency f_{exc} .

61 (new). The method of claim 58, further comprising:

providing said resonator with a substantially circular center conductor, having a diameter sufficient to support at least a pair of orthogonal degenerate modes corresponding to said frequency f_{res} ;

connecting said input coupler and said output coupler to first and second selected locations, respectively, spaced apart approximately $\pi/2$ radians, on a circumference of the circular conductor.

62 (new). The method of claim 56, further comprising providing said resonator as a cavity-type resonator that supports at least a pair of orthogonal degenerate modes at said frequency f_{res} , and providing said evanescent wave probe as an aperture at a selected location in a shielding wall of said resonator, where a degenerate mode amplitude associated with said input coupler is much larger than a degenerate mode amplitude associated with said output coupler.

63 (new). The method of claim 45, further comprising:

providing an input signal coupler and an output signal coupler for a resonator, associated with said probe and having at least one node point at a location not on a circumference of the resonator for an input signal with said frequency f_{res} ;

providing said excitation signal to the input coupler, where said input signal produces an evanescent wave at said probe that is strongly coupled to the input coupler and the output coupler is coupled to the node point, when said sample is absent; and

sensing a non-zero portion of said output signal with frequency component f_{res} at the node point, representing said interaction of said evanescent wave and sample portion.

64 (new). The method of claim 63, further comprising:

adjusting at least one parameter associated with at least one of said input coupler, said output coupler and said resonator so that, when said sample is absent, an amplitude of an output signal received at said output coupler is minimized; and

sensing said impedance signal at said output coupler said sample is present.

65 (new). The method of claim 45, further comprising:

providing first and second, substantially identical resonators, where the first resonator, but not the second resonator, is connected to said evanescent wave probe and is located adjacent to said sample portion;

providing said excitation signal along the first and second resonators to produce said evanescent wave;

forming a difference of first and second resonator output signal components for said frequency component f_{res} , representing said interaction of said evanescent wave with sample portion.

66 (new). The method of claim 65, further comprising:

adjusting an amplitude and said resonant frequency of said second resonator so that a magnitude of said difference is minimized when said sample is absent; and

sensing said difference of said first and second output signal components when said sample is present.

Respectfully Submitted,

A handwritten signature in black ink, consisting of a stylized 'X' followed by a horizontal line.

Xiao-Dong Xiang

Co-inventor

Date: January 16, 2004